

AWARD NUMBER: DM140417

TITLE: Reducing Injuries with Training Enhancement, Targeted Rehabilitation and Core Conditioning (RITE-TRACC)

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REPORT DATE: Mar 2020

TYPE OF REPORT: Final

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

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REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
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1. REPORT DATE March 2020		2. REPORT TYPE Final		3. DATES COVERED 05/07/2015 - 11/06/2019	
4. TITLE AND SUBTITLE Reducing Injuries with Training Enhancement, Targeted Rehabilitation, and Core Conditioning (RITE-TRACC)				5a. CONTRACT NUMBER DM140417	
				5b. GRANT NUMBER DM140417	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Sarah J. de la Motte, PhD, MPH, ATC Carolyn E. Dartt, MEd, ATC E-Mail: sarah.delamotte@usuhs.edu				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Uniformed Services University of the Health Sciences 4301 Jones Bridge Road Bethesda, MD 20814				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel Command Fort Detrick, Maryland 21702-5012				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT Our primary research objective is to develop predictive models and an accompanying injury prevention curriculum for lower extremity musculoskeletal injury (LE MSK-I) and successful return to duty in a training Marine population at the School of Infantry-West at Camp Pendleton (SOI-West). Non-combat related musculoskeletal injury (MSK-I) is the largest threat to military health and accounts for over 20% of outpatient visits in the active duty population. Reducing physical training-related MSK-I has been identified as a top priority within the military. Almost 40% of MSK-I sustained from military training and sport-related activities are sprains/strains and overuse injuries (e.g. medial tibial stress syndrome, stress fracture) of the lower extremity. Recent studies have identified a broad range of LE MSK-I risk factors in military and athletic populations, including movement patterns, psychological readiness, lifestyle behaviors, physical fitness, and injury history, many of which can be modified with targeted interventions.					
15. SUBJECT TERMS Musculoskeletal Injury Risk, Movement Screening, Military Training, Movement Re-training, Injury Prevention Curriculum					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Unclassified	18. NUMBER OF PAGES 41	19a. NAME OF RESPONSIBLE PERSON USAMRMC
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified			19b. TELEPHONE NUMBER (include area code)

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1. INTRODUCTION: *Narrative that briefly (one paragraph) describes the subject, purpose and scope of the research.*

Reducing physical training-related MSK-I has been identified as the top priority for injury prevention within the military. Almost 40% of MSK-I sustained from military training and sport-related activities are sprains/strains and overuse injuries of the lower extremity. Recent studies have identified a broad range of LE MSK-I risk factors in military and athletic populations, including movement patterns, lifestyle behaviors, and injury history, many of which can be modified with targeted interventions. However, how these risk factors develop and/or change over training cycles is not known. Our primary objective is to develop predictive models and an accompanying injury prevention curriculum for lower extremity musculoskeletal injury (LE MSK-I) in a training Marine population at the School of Infantry at Camp Pendleton (SOI-West). By combining rapid movement screening with several existing data sources and lifestyle behaviors collected from male Marines at the School of Infantry-West, we aim to identify factors that prospectively predict LE MSK-I, as well as identify how these risk factors manifest over the course of training. Specific factors to be studied include: balance and movement quality, body mass index, and injury history. Consequently, our secondary aim is to develop a targeted injury prevention curriculum within the SOI to address MSK risk factors at this critical early stage.

2. KEYWORDS: *Provide a brief list of keywords (limit to 20 words).*

Musculoskeletal Injury Risk, Movement Screening, Military Training, Movement Re-training, Injury Prevention Curriculum

3. ACCOMPLISHMENTS: *The PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction.*

What were the major goals of the project?

List the major goals of the project as stated in the approved SOW. If the application listed milestones/target dates for important activities or phases of the project, identify these dates and show actual completion dates or the percentage of completion.

Specific Aim1: Develop predictive models for lower extremity musculoskeletal injury (LE MSK-I) and successful return to duty based on current injury history, functional movement, physical fitness, lifestyle behaviors, and psychosocial status in a training Marine population.

Specific Aim 2: Determine the effects of an integrated comprehensive movement re-training program for LE MSK-I primary and recurrent injury prevention in training Marines.

Major Task 1: Obtain all regulatory permissions

- Milestone: Local IRB approval at USU, completed 2 May 2016
- Milestone: HRPO approval and local IRB approval/exemption, completed 15 Jun 2016

Major Task 2: Hire and train study staff; Organize for study implementation

- Milestone: Research staff trained, 19 Sep 2016
- Milestone: Complete MOOP/SOPs and databases, order supplies, 13 Sep 2016
- Milestone: Sub-award approval, completed 6 July 2015

Major Task 3: Recruit, screen and test participants

- Milestone: 1st participant consented, screened and enrolled, completed 13 Sep 2016
- Milestone: Study begins, completed 13 Sep 2016
- Milestone: Complete participant testing, completed 20 May 2019
- Milestone: Complete implementation collection, completed 20 May 2019
- Milestone: Complete data entry for demographic, anthropometric, movement screening, and psychological measures, completed 10 Aug 2019

Major Task 4: Analyze Data

- Milestone: Complete Databases (Year 1), completed 1 July 2017
- Milestone: Complete Databases (Year 2), completed 25 Oct 2019
- Milestone: Statistical analyses complete, completed 20 Feb 2020
- Milestone: Final results and conclusions shared/discussed with all investigators, completed 6 Mar 2020

Major Task 5: Prepare reports and recommendations

- Milestone: Report findings, completed 6 Mar 2020
- Milestone: Advance knowledge injury prevention of our wounded warriors, ongoing

What was accomplished under these goals?

For this reporting period describe: 1) major activities; 2) specific objectives; 3) significant results or key outcomes, including major findings, developments, or conclusions (both positive and negative); and/or 4) other achievements. Include a discussion of stated goals not met. Description shall include pertinent data and graphs in sufficient detail to explain any significant results achieved. A succinct description of the methodology used shall be provided. As the project progresses to completion, the emphasis in reporting in this section should shift from reporting activities to reporting accomplishments.

AIM 1

The first aim of this study was to develop predictive models for lower extremity (LE) musculoskeletal injury (MSK-I) based on injury history, functional movement, physical fitness, and lifestyle behaviors. To accomplish this aim, consented Marines who had completed Basic Training and presented to the School of Infantry-West (SOI-W) at Camp Pendleton for follow-on training were administered a survey and performed, as time allowed, a movement screening at entry to and graduation from SOI-W. SOI-W training consists of two courses: Marine Combat Training (MCT) and Infantry Training Battalion (ITB). MCT is a condensed 29-day course for all non-infantry Marines. ITB is a 59-day course for Marines wishing to attain an infantry Military Occupational Specialty (MOS). While we did enroll and evaluate MCT Marines, the main focus and outcome of interest was LE MSK-I for Marines completing Infantry Training (ITB). All Marines enrolled in this study were male; SOI-W began integrating female Marines into MCT courses in early 2018, however no female Marines were enrolled into the study.

Baseline Questionnaire

The baseline survey administered at entry to SOI-W included questions regarding previous tobacco use, perceived overall health and fitness, overall health in the past year, and previous ankle sprain. The baseline survey also included questions on self-reported history of MSK-I and musculoskeletal pain (MSK-P) during Basic Training, as well as care-seeking behaviors for those MSK-I and MSK-P during Basic Training. In addition, subjects were asked to report whether their MSK-I from Basic Training had healed at entry to SOI-W, and whether they were currently experiencing MSK-P at entry to SOI-W. Lastly, subjects identified which SOI-W course they were entering (MCT or ITB), and reported their date of birth in order to calculate age.

Movement Screening

For those Marines who were available to be screened, movement screening consisted of the Landing Error Scoring System (LESS) and three parts of the Functional Movement Screen: the In-Line Lunge (ILL), the Active Straight Leg Raise (ASLR), and the Trunk Stability Push-Up (TSPU) tests. Due to various logistical considerations on available testing days, some Marines were only able to complete partial screens. Subjects also self-reported height and weight during the movement screening, from which Body Mass Index (BMI) was calculated.

Post-Graduation Questionnaire

A survey was also administered at graduation from SOI-W which included questions regarding self-reported MSK-I during SOI-W training. Subjects indicated their MOS attained. For final analyses, ITB MOS was collapsed into two categories, Infantry Rifleman (0311) and Infantry Non-Rifleman (0300, 0331, 0341, 0351, 0352).

Outcome Variable

The main outcome variable of interest was any LE MSK-I sustained during ITB. LE MSK-I was determined from the post-graduation questionnaire, as well as medically documented measures from the Defense Medical Surveillance System (DMSS). Associations between possible predictors and the outcome variable were first assessed using Pearson chi-square tests for categorical variables and independent t-tests for continuous measures; predictor variables with a p-value ≤ 0.25 in the univariate assessments were included in a multivariate logistic regression model.

RESULTS

A total of 1,122 Marines were consented and enrolled in the full study at entry to SOI-W; 9.6% (n=108) entered MCT training and 90.4% (n=1,014) entered ITB. Sixty percent (n=673) of subjects in the full study were able to return for post-testing upon graduation from SOI-W (n=88 from MCT; n=585 from ITB). Subjects ranged in age from 18.0 to 28.7 years old (mean \pm SD: 19.74 \pm 1.72 years) (**Table 1**). Infantry Rifleman MOS was attained by 180 (59%) Marines, while the remaining 118 (39%) attained a non-rifleman infantry MOS. See **Table 2** for a summary of MOS attained by group. Full pre- and post-training data was collected on 306 subjects who completed ITB training for Aim 1.

Lower Extremity MSK-I During Infantry Training

Univariate modeling between LE MSK-I during ITB training and possible predictors revealed five variables with p-values ≤ 0.25 : MOS, MSK-P during Basic Training, MSK-P upon entry to SOI-W, and ASLR score. Seeking medical attention for MSK-I during Basic Training ($X^2=5.19$, $p=0.04$) and self-reported MSK-P during Basic Training ($X^2=4.26$, $p=0.04$) were the strongest univariate predictors. **Table 3** describes the associations between each possible predictor variable and LE MSK-I during ITB training. While the multivariate model was significant ($X^2_{(4)}=10.58$, $p=0.03$), none of the predictors for MSK-I during ITB training had p-values < 0.05 (**Table 4**). However, MSK-P during Basic Training and ASLR both had p-values=0.07, suggesting they may be of some importance. A sub-analysis was performed on the subjects who reported MSK-I during Basic Training (n=70). Seeking medical attention for an MSK-I during Basic Training was a significant predictor of LE MSK-I during ITB training ($p=0.04$); among individuals who self-reported an MSK-I during basic training, those who did not seek medical attention had a 18% lower odds of reporting an LE MSK-I during ITB training than those who did seek medical attention for their MSK-I during basic training (**Table 5**). However, when controlling for age and MOS, the logistic regression model was not statistically significant ($X^2(3)=4.45$, $p=0.22$).

DISCUSSION

The full logistic regression model explained 7.6% (Nagelkerke R^2) of variance in LE MSK-I during ITB training, and correctly classified 90.5% of cases. Although none of the predictor variables included in the full model reached $p < 0.05$, MSK-P during Basic Training and the ASLR score both neared statistical significance ($p = 0.07$). Furthermore, these two variables may more importantly, be clinically significant. From a clinical standpoint, ASLR score may be a modifiable risk factor, and could be addressed via interventions early in training. In addition, MSK-P during basic training is important to consider, as experiencing MSK-P during Basic Training may be indicative of early stages of overuse injuries, which can worsen during further training, causing lost duty days and training attrition. Indeed current MSK-P upon entry to SOI-W was univariately significantly associated with LE MSK-I during ITB training. Thus, we chose strategies to mitigate MSK-P and address ASLR in our Injury Prevention Curriculum (**Aim 2: see below**). Previous research has also shown that nutrition, tobacco use and sleep are associated with LE MSK-I. While these were not fully able to be captured in our analyses, they were nonetheless deemed important health factors and were addressed in our IPC.

AIM 2

The second aim of this study was to determine the effects of our integrated comprehensive injury prevention curriculum in Marines undergoing ITB training at SOI-W, which was designed using findings from Aim 1. Aim 2 enrolled a new population of Marines who underwent the same movement screening and survey procedures as Aim 1, and incorporated the development and implementation of a targeted, specific injury prevention curriculum (IPC) to be integrated into ITB training. As in Aim 1, consented Marines were administered a survey and performed, as time allowed, a movement screening at entry to and graduation from ITB. The Aim 1 ITB subjects served as a historical control group; the effects of the IPC were observed in the data collected from consented Marines by comparing LE MSK-I and MSK-P during ITB training. Finally, we evaluated movement changes from the Aim 2 cohort compared to those in Aim 1.

Aim 2 Post-Graduation Questionnaire

As in Aim 1, a survey at graduation from ITB included questions regarding self-reported MSK-I during ITB training, and self-reported MSK-P upon graduation from ITB. Subjects were also asked to indicate their pain level on a scale of 0-10, based on the Defense Veterans' Pain Rating Scale (DVPRS). Subjects in Aim 2 also completed questions regarding their perceptions regarding the dynamic warm up and cool down, and frequency of participation in the dynamic warm up and cool down.

INJURY PREVENTION CURRICULUM

Using findings from Aim 1, the injury prevention curriculum (IPC) was developed by study staff in coordination with ITB command staff, ITB combat instructors, US Marine Corps Force Fitness Instructors, US Marine Corps SMIP athletic trainers, and US Navy SMART Center physicians and athletic trainers. The IPC included a standardized dynamic warm up and cool down designed to address both the modifiable factors from Aim 1, as well as targeted sleep hygiene, hydration, and nutrition--lifestyle factors that have also been associated with LE MSK-I and are known to improve overall health and well-being. The targeted nutrition and hydration education was provided in conjunction with the existing education as part of the ITB curriculum, and was derived from evidence-based research and education. This education provided information regarding hydration status, healthy meal options on base and during liberty, and fueling for performance. The sleep hygiene education was also designed to be provided in conjunction with the existing education in the ITB curriculum, and included material on strategies to improve sleep quality during training, as well as the effects of sleep on performance.

The dynamic warm up and cool down were taught by study staff to the ITB combat instructors using a train-the-trainer method, and were designed to be incorporated into the existing training structure before and after physical training activities and evaluations, range movements, and hikes. The dynamic warm up was designed to be performed 3-4 times per week for 12-15 minutes per session, and included warm-up, flexibility, and movement quality/neuromuscular control components. The standardized cool down was also designed to be performed 3-4 times per week for 10-12 minutes per session, and included flexibility components and a brief recovery period. The dynamic warm up and cool down were implemented by the Combat Instructors within ITB, and study staff were available to provide feedback on how to instruct and cue the warm up and cool down activities. Study staff also received feedback from command staff and Combat Instructors on the IPC, and were able to adjust the IPC to continue to meet the needs of the Combat Instructors and ITB students.

Outcome Variables

The main outcome variable of interest was lower extremity MSK-I during ITB training for Aim 2 compared to Aim 1. We also assessed changes in movement screen scores from pre-post ITB training for Aim 2 compared to Aim 1. Multivariate modeling controlled for final MOS attained and ITB training company. Changes in movement screening scores were assessed using Kolmogorov-Smirnov non-parametric tests.

RESULTS

A total of 1,122 Marines were consented and enrolled in the full study at entry to SOI-W; 9.6% (n=108) entered MCT training and 90.4% (n=1,014) entered ITB. Sixty percent (n=673) of subjects in the full study were able to return for post-testing upon graduation from SOI-W (n=88 from MCT; n=585 from ITB). Subjects ranged in age from 18.0 to 28.7 years old (mean \pm SD: 19.74 \pm 1.72 years) (**Table 1**). Infantry Rifleman MOS was attained by 180 (59%) Marines, while the remaining 118 (39%) attained a non-rifleman infantry MOS. See **Table 2** for a summary of MOS attained by group. Full pre- and post-training data was collected on 279 subjects who completed ITB training for Aim 2.

LE MSK-I During Infantry Training

Table 6 shows descriptives of LE MSK-I by Aim cohort, and **Table 7** shows a summary of Marines enrolled by training company. Our multivariate model was significant (p=0.01), and showed that, compared to ITB Marines from Aim 1, Marines in Aim 2 reduced their odds of reporting LE MSK-I by almost half (p=0.03, OR=0.49, 95% CI: 0.26-0.95)(**Table 8**). ITB training companies Charlie and Delta also had lower odds of reporting LE MSK-I compared to the Alpha training company.

Movement Changes Post-ITB Training

Kolmogorov-Smirnov (K-S) nonparametric tests were performed to determine if ILL, ASLR, and TSPU movement changes pre- to post-graduation differed for Aim 2 compared to Aim 1. The changes in ILL (D=0.63, p=0.82), ASLR (D=0.60, p=0.86), and TSPU (D=0.02, p=1) from ITB entry to graduation did not differ for Aim 2 subjects compared to Aim 1.

Self-Reported Compliance with the IPC During Infantry Training

In order to monitor compliance with the IPC during training, study staff attended training rotations and range movements when possible. With multiple training companies and several platoons per training company, attendance by study staff at every implementation of the IPC was not accessible to study staff due to remote locations the IPC was performed (i.e. desert range before hikes) and therefore not possible to directly observe each time it was planned to be performed. Therefore, we relied on questions regarding completion of the IPC components were included on the post-graduation questionnaire in order to further assess compliance with the IPC. A subset of Aim 2

subjects (n=124) were also asked how frequently they completed the dynamic warm up and stretching routines led by combat instructors. Subjects were able to choose responses that ranged from “never” to “6x per week or more.” Subjects reported a wide array of frequencies of performing the dynamic warm up and stretching led by Combat Instructors. 1% (n=2/124) reported never completing the dynamic warm up, 37% (n=46/124) reported completing it once per week or less, 56% (n=69/124) reported completing it 2-3 times per week, and 5% (n=7/124) reported completing the dynamic warm up 4-5 times per week led by Combat Instructors. 7% (n=8/123) reported never completing the stretching when led by Combat Instructors, 37% (n=45/123) reported completing the stretching once per week or less, 49% (n=60/123) reported completing it 2-3 times per week, 5% (n=6/123) reported completing it 4-5 times per week, and 3% (n=4/123) reported completing the stretching 6 times per week or more when led by Combat Instructors. See **Table 9** and **Table 10** for a summary of self-reported compliance with the dynamic warm up by training company.

Subjects were also asked how frequently they completed the dynamic warm up and stretching routines on their own time. Subjects were able to choose responses that ranged from “never” to “6x per week or more.” Subjects also reported a wide array of frequencies of performing the dynamic warm up and stretching on their own. 32% (n=39/121) reported never completing the dynamic warm up on their own time, 23% (n=28/121) reported completing the dynamic warm up once per week or less, 33% (n=40/121) reported completing it 2-3 times per week, 7% (n=9/121) reported completing it 4-5 times per week, and 4% (n=5/121) reported completing the dynamic warm up 6 times per week or more on their own time. 28% (n=33/120) reported never completing the stretching on their own time, 25% (n=30/120) reported completing the stretching once per week or less, 35% (n=42/120) reported completing it 2-3 times per week, 8% (n=10/120) reported completing it 4-5 times per week, and 4% (n=5/120) reported completing the stretching 6 times per week or more on their own time. See **Table 9** and **Table 10** for a summary of self-reported compliance with the stretching exercises by training company.

Within this subset of Marines, when controlling for MOS and initial pick-up company, none of the self-report DWU nor self-report stretching variables appeared to influence reported LE MSK-I (model p=0.66), and did also not appear to influence self-reported MSK-P during ITB training (model p=0.18).

Self-Reported Effects of IPC on MSK-P During Infantry Training

Aim 2 subjects who reported MSK-P (n=51) during ITB training were also asked whether the IPC had any effect (positively or negatively) on their pain; 49% (n=25) said yes and 51% (n=26) said no, and then rated how the dynamic warm up and stretching affected their MSK-P on a 5-point Likert type scale. Responses were collapsed into 3 categories (made it better, had no effect, and made it worse). Almost three-quarters (73%; n=24/33) responded that the dynamic warm up made their MSK-P better, 21% (n=7/33) responded that the dynamic warm up had no effect on their MSK-P, and 6% (n=2/33) indicated that the dynamic warm up made their MSK-P worse during ITB training. Overall, 75% (n=21/28) indicated that the stretching made their MSK-P better, while 25% (n=7/28) indicated that the stretching had no effect on their MSK-P during ITB training. See **Table 11** for a summary of the effects of the IPC on MSK-P during ITB training.

GOALS NOT MET

We originally intended to include measures of physical fitness and psychological hardiness in our study. However, the data source for the psychological hardiness measures, which is an existing data source collected upon entry to Basic Training, was not available for a large portion of our sample and therefore were not ultimately included for analysis. Furthermore, we were unable to/could not include physical fitness measures because fitness scores were not considered

graduation requirements. While most companies completed the physical fitness and combat fitness tests during training, individual Marines' final scores were not kept in a standardized manner and were not accessible to study staff. We did capture data on the MOS-specific tests, which were training requirements, but the pass-rate for subjects who graduated from training was 100%, meaning it would not have helped in risk factor statistical modeling.

An original sub-aim for the study was to study movement upon return to duty from musculoskeletal injury. Due to personnel constraints and logistical considerations we were not able to accomplish this sub-aim. Marines who were dropped from training and completing rehabilitation from due to MSK-I were not as accessible due to their medical appointment schedules; ultimately, it was not feasible for neither study staff nor command staff in the rehabilitation company and reception battalion to assist study staff in tracking individual subjects for return to duty testing.

What opportunities for training and professional development has the project provided?

If the project was not intended to provide training and professional development opportunities or there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe opportunities for training and professional development provided to anyone who worked on the project or anyone who was involved in the activities supported by the project. “Training” activities are those in which individuals with advanced professional skills and experience assist others in attaining greater proficiency. Training activities may include, for example, courses or one-on-one work with a mentor. “Professional development” activities result in increased knowledge or skill in one’s area of expertise and may include workshops, conferences, seminars, study groups, and individual study. Include participation in conferences, workshops, and seminars not listed under major activities.

Investigators have presented study findings at numerous national and international conferences: National Athletic Trainers’ Association (NATA) Annual Meeting & Clinical Symposia – 2017-2019; American College of Sports Medicine Annual Meeting – 2018; Military Health System Research Symposium – 2017-2019; Far West Athletic Trainers’ Association Annual Meeting – 2018; International Congress of Soldiers’ Physical Performance – 2017; 2020. Furthermore, investigators led a Peer-to-Peer Discussion Forum consisting of lessons learned from the current study and strategies for other researchers and clinicians to develop and implement their own injury prevention programs. Further, in May 2019, investigators held a one-on-one meeting at the Vail Injury Prevention Symposium with an internally renowned sports epidemiologist, Dr. Caroline Finch, to discuss injury prevention program implementation issues and possible statistical methods for the current study.

How were the results disseminated to communities of interest?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe how the results were disseminated to communities of interest. Include any outreach activities that were undertaken to reach members of communities who are not usually aware of these project activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Preliminary results of this study have been disseminated to the military and civilian research communities via presentations, posters, and abstracts at numerous national and international professional conferences. We also provided preliminary results and updates to SOI-W command staff in several briefings throughout the course of the study.

What do you plan to do during the next reporting period to accomplish the goals?

If this is the final report, state “Nothing to Report.”

Describe briefly what you plan to do during the next reporting period to accomplish the goals and objectives.

Nothing to report

4. IMPACT: *Describe distinctive contributions, major accomplishments, innovations, successes, or any change in practice or behavior that has come about as a result of the project relative to:*

What was the impact on the development of the principal discipline(s) of the project?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe how findings, results, techniques that were developed or extended, or other products from the project made an impact or are likely to make an impact on the base of knowledge, theory, and research in the principal disciplinary field(s) of the project. Summarize using language that an intelligent lay audience can understand (Scientific American style).

We saw that many clinical variables were important from a univariate standpoint in evaluating possible predictors of LE MSK-I. Both hamstring flexibility as assessed by the ASLR, and MSK-P during Basic Training is important to consider, as experiencing MSK-P during Basic Training may be indicative of early stages of overuse injuries, which can worsen during further training. Identifying that Marines are reporting MSK-P in our study, but not necessarily seeking care for their MSK-P is an important factor to consider in future studies. Identifying barriers to reporting and seeking care for MSK issues is of paramount importance in order to fully characterize MSK-I and accordingly, develop appropriate preventative measures. Our group plans further study in this specific area.

Our results showing that LE MSK-I during ITB training was lower in the group that performed our Injury Prevention Curriculum (IPC). However, the exact mechanism of this effect is unknown. The IPC did not appear to influence functional movement (ILL, ASLR, or TSPU) changes over ITB training. It could be that the FMS tests may not be sensitive enough to reflect changes in functional movement over time; further research could be performed using more sensitive measures of functional movement to better determine changes in movement quality over training.

The IPC was developed to target both movement patterns and other important health factors that have been shown to influence MSK-I risk. While we were unable to directly assess this, the IPC may have influenced Marines' behaviors and attitudes towards performance optimization and MSK-I. For example, subjects reported that they completed components of the IPC both led by Combat Instructors and on their own time. The IPC standardized a warm-up and cool-down, which provided the training Marines with a resource to utilize on their own to properly prepare for, or recover from, training. While integrating injury prevention and performance optimization components into the training curriculum is important, it is also important to understand that providing targeted resources and education to training Marines may also be effective in mitigating the risk of MSK-I.

There are several limiting factors when interpreting the results of the IPC in this study. The IPC was implemented at the same time as the Program of Instruction (POI) during ITB changed slightly, a change out of our control. While the overall training requirements remained the same, certain events and training rotations were moved to different timepoints within the training cycle. We are unable to determine if these changes may have influenced Marines' recovery or LE MSK-I rates. However, as stated above, by attempting to provide Marines IPC materials to perform on their own, it is our goal that the performance of the dynamic warm-up and cool-down activities continue. It would therefore be possible to return to the study site for additional follow-on investigations to determine the effects of the IPC within a new cohort undergoing the revised POI.

Finally, the findings of this study will add to the growing body of research regarding musculoskeletal injury risk, injury prevention program development and injury prevention program implementation in military populations. Lessons learned can also be applied to the civilian sports world. In addition to identifying and mitigating potential MSK-I risk, this study also documents the successful integration of injury prevention programs in a training population; the methods used to implement the injury prevention program can be applied to future research.

What was the impact on other disciplines?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe how the findings, results, or techniques that were developed or improved, or other products from the project made an impact or are likely to make an impact on other disciplines.

Our findings have the potential to make an impact on clinicians practicing in military training environments, as well as their Commands. Specifically, understanding that hamstring flexibility and musculoskeletal pain are important for this demographic can assist clinicians with partnering with training Commands to find ways to reduce MSK-I risk. Our IPC also is likely to have an impact for Commands and training instructors. Knowing that standardized, targeted integrated training has been developed, may be effective at reducing LE MSK-I, and MSK-P if adhered to may assist training Commands in addressing MSK-I in their trainees.

What was the impact on technology transfer?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe ways in which the project made an impact, or is likely to make an impact, on commercial technology or public use, including:

- *transfer of results to entities in government or industry;*
- *instances where the research has led to the initiation of a start-up company; or*
- *adoption of new practices.*

While the IPC was specifically designed for the ITB training population at SOI-W, the design and implementation plan could be transferred to other government entities, as well as to civilian sports groups.

What was the impact on society beyond science and technology?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe how results from the project made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world on areas such as:

- *improving public knowledge, attitudes, skills, and abilities;*
- *changing behavior, practices, decision making, policies (including regulatory policies), or social actions; or*
- *improving social, economic, civic, or environmental conditions.*

The findings from our study provide strong leverage for developing a policy of targeted injury prevention program design and implementation for each unique training environment. While the Marine Corps has attempted to standardize its training on both the East and West Coasts, each environment is unique, including in geography, weather, personnel and demographics. Our results are specific to SOI-W and ITB at Camp Pendleton, encompassing the unique environment in which the IPC was created. As we followed the principles of Implementation Science and Dissemination in our study, each training environment would need to be separately evaluated, and an accompanying IPC developed with all involved parties. This is quite different from a one-size-fits-all approach to injury prevention that is now commonplace in the military services. Such an approach may seem daunting and infeasible for military training environments. However, as the goal is the reduction of LE MSK-I and the sustained health and well-being of Service members, if such an individualized approach is effective, policy makers may want to consider directing more resources towards such measures.

- 5. CHANGES/PROBLEMS:** *The PD/PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction. If not previously reported in writing, provide the following additional information or state, "Nothing to Report," if applicable:*

Changes in approach and reasons for change

Describe any changes in approach during the reporting period and reasons for these changes. Remember that significant changes in objectives and scope require prior approval of the agency.

Nothing to Report

Actual or anticipated problems or delays and actions or plans to resolve them

Describe problems or delays encountered during the reporting period and actions or plans to resolve them.

Nothing to Report

Changes that had a significant impact on expenditures

Describe changes during the reporting period that may have had a significant impact on expenditures, for example, delays in hiring staff or favorable developments that enable meeting objectives at less cost than anticipated.

Nothing to Report

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Describe significant deviations, unexpected outcomes, or changes in approved protocols for the use or care of human subjects, vertebrate animals, biohazards, and/or select agents during the reporting period. If required, were these changes approved by the applicable institution committee (or equivalent) and reported to the agency? Also specify the applicable Institutional Review Board/Institutional Animal Care and Use Committee approval dates.

Significant changes in use or care of human subjects

None

Significant changes in use or care of vertebrate animals

N/A

Significant changes in use of biohazards and/or select agents

N/A

- 6. PRODUCTS:** *List any products resulting from the project during the reporting period. If there is nothing to report under a particular item, state "Nothing to Report."*

• **Publications, conference papers, and presentations**

Report only the major publication(s) resulting from the work under this award.

Journal publications. *List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Identify for each publication: Author(s); title; journal; volume; year; page numbers; status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

- de la Motte SJ, Gribbin TC, Deuster PA. Optimizing Musculoskeletal Performance Through Injury Prevention. J Spec Oper Med. Winter 2017; 17(4):97-101.

- Clifton DR, de la Motte SJ. Letter to the Editor: Measuring True Accuracy of Self-reported Injuries. *Musculoskelet Sci Pract.* 2019 Jul;42:e1.
- Clifton DR, Gribbin TC, Beutler AI, de la Motte SJ. See the forest for the trees: making injury risk mitigation programs work for you. *Current Sports Medicine Reports.* Accepted November 2019.

Books or other non-periodical, one-time publications. *Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like. Identify for each one-time publication: author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (e.g., book, thesis or dissertation); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Nothing to report

Other publications, conference papers and presentations. *Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication as noted above. List presentations made during the last year (international, national, local societies, military meetings, etc.). Use an asterisk (*) if presentation produced a manuscript.*

- Dartt CE, Donahue CC, Gribbin TC, Deuster PA, de la Motte SJ. Considerations for Implementing Injury Prevention Exercises In U.S. Marine Corps Training. Oral Presentation at the National Athletic Trainers' Association Clinical Symposia. Houston, TX, 06/28/2017.
- Gribbin TC, Beutler AI, de la Motte SJ. Leaving the Lab and Stepping onto the Battlefield: Using 15 Years of Injury Prevention Research in the U.S. Military to Guide the Future. Featured Presentation at the National Athletic Trainers' Association Clinical Symposia. Houston, TX, 06/28/2017.
- de la Motte SJ, Gribbin TC, Deuster PA. Translating Injury Prevention Research into Practice - Expanding on the Traditional Public Health Model for Injury Prevention in the Military. Oral Presentation at the Military Health System Research Symposium. Kissimmee, FL, 08/30/2017.
- de la Motte SJ. Primary Prevention – Global Prevention for All, and Total Force Fitness. Invited Presentation presented at 4th International Congress on Soldiers' Physical Performance; Melbourne, Victoria, Australia. 12/01/2017.
- Dartt CE, de la Motte SJ, Deuster PD, Gribbin TC. Reliability of Evaluating the Single Leg Squat Using Multiple Assessment Methods. Oral Presentation at the American College of Sports Medicine Annual Meeting. Minneapolis, MN, 06/01/2018.
- de la Motte SJ, Dartt CE, Donahue CC. The Complexity of Implementing Injury Prevention Programs – How Do We Get These to Work? A Peer to Peer Discussion Forum at the National Athletic Trainers' Association Clinical Symposia. New Orleans, LA, 06/27/2018.
- Donahue CC, Gribbin TC, Dartt CE, Kazman JB, de la Motte SJ. Factor Structure of a Knowledge, Attitude and Beliefs Survey on Lower Extremity Injury in a Military Training Setting. Oral Presentation at the National Athletic Trainers' Association Clinical Symposia. New Orleans, LA, 06/27/2018.
- Dartt CE, Donahue CC, Gribbin TC, Deuster PA, de la Motte SJ. Assessing Changes in Knowledge Attitudes, and Beliefs Towards Injury Prevention During Marine Corps Training. Oral Presentation at the National Athletic Trainers' Association Clinical Symposia. New Orleans, LA, 06/27/2018.
- Donahue CC, Dartt CE, Gribbin TC, de la Motte, SJ. Designing an Injury Prevention Curriculum in a Military Training Environment. Oral Presentation at the Military Health System Research Symposium. Kissimmee, FL, 08/22/2018.
- Dartt CE, Donahue CC, Gribbin TC, Deuster PA, de la Motte SJ. Assessing Changes in Knowledge, Attitudes, and Beliefs Towards Injury Prevention During Marine Corps Training. Oral Presentation at the Military Health System Research Symposium. Kissimmee, FL, 08/22/2018.

- Clifton DR, Dartt CE, de la Motte SJ. Self-reported general health and fitness among U.S. Service members entering secondary training. Oral Presentation at the National Athletic Trainers' Association Clinical Symposia. Las Vegas, NV, 06/26/2019.
- Cone BL, Tra J, Dartt CE, Clifton DR, de la Motte, SJ. The impact of limited flexibility and previous musculoskeletal injury on likelihood of injury in U.S. Service members during secondary training. Oral Presentation at the National Athletic Trainers' Association Clinical Symposia. Las Vegas, NV, 06/26/2019.
- Dartt CE, Clifton DR, Gribbin TC, Tra J, de la Motte SJ. Associations Between an Integrated Musculoskeletal Injury Risk Mitigation Program and Self-Reported Pain During US Military Training. Oral Presentation at the Military Health System Research Symposium. Kissimmee, FL, 08/21/2019.
- de la Motte SJ. Accurate Prediction Depends on Accurate Assessment: Self-Limiting Beliefs and Cultural Barriers Influence Musculoskeletal Injury Reporting. Invited Presentation presented at the International Congress on Soldiers' Physical Performance. Quebec City, Quebec, Canada, 02/11/2020.

Website(s) or other Internet site(s)

List the URL for any Internet site(s) that disseminates the results of the research activities. A short description of each site should be provided. It is not necessary to include the publications already specified above in this section.

None

Technologies or techniques

Identify technologies or techniques that resulted from the research activities. Describe the technologies or techniques were shared.

None

Inventions, patent applications, and/or licenses

Identify inventions, patent applications with date, and/or licenses that have resulted from the research. Submission of this information as part of an interim research performance progress report is not a substitute for any other invention reporting required under the terms and conditions of an award.

None

Other Products

Identify any other reportable outcomes that were developed under this project. Reportable outcomes are defined as a research result that is or relates to a product, scientific advance, or research tool that makes a meaningful contribution toward the understanding, prevention, diagnosis, prognosis, treatment and /or rehabilitation of a disease, injury or condition, or to improve the quality of life. Examples include:

- *data or databases;*
- *physical collections;*
- *audio or video products;*
- *software;*
- *models;*

- *educational aids or curricula;*
- *instruments or equipment;*
- *research material (e.g., Germplasm; cell lines, DNA probes, animal models);*
- *clinical interventions;*
- *new business creation; and*
- *other.*

For the injury prevention curriculum in this project, we developed a standardized warm up and cool down for implementation during training. This was taught to Combat Instructors, and we also provided with reference cards and educational handouts for this warm up and cool down during the instruction. Additionally, we developed targeted educational posters for the training populations, which were hung up in visible areas. These educational posters included content regarding sleep hygiene during training, nutritional education and ideas to implement during training, and education about hydration status.

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Provide the following information for: (1) PDs/PIs; and (2) each person who has worked at least one person month per year on the project during the reporting period, regardless of the source of compensation (a person month equals approximately 160 hours of effort). If information is unchanged from a previous submission, provide the name only and indicate “no change”.

Example:

Name: Mary Smith
Project Role: Graduate Student
Researcher Identifier (e.g. ORCID ID): 1234567
Nearest person month worked: 5

Contribution to Project: Ms. Smith has performed work in the area of combined error-control and constrained coding.

Funding Support: The Ford Foundation (Complete only if the funding support is provided from other than this award.)

Name	Sarah J. de la Motte, PhD, MPH, ATC
Project Role	Principal Investigator
Researcher Identifier:	
Nearest person month worked:	4
Contribution to Project	Dr. de la Motte is the Principal Investigator on this project. She was responsible for the overall study design and implementation, coordination with study site personnel, and is overseeing data analysis and manuscript preparation.
Funding Support:	Department of Defense/Uniformed Services University
Name	Timothy Gribbin, MEd, ATC
Project Role	Research Associate
Researcher Identifier:	
Nearest person month worked:	2
Contribution to Project	Mr. Gribbin assisted in data collection, data management, creating study forms, IRB coordination, consenting, and manuscript preparation.
Funding Support:	The Consortium for Health and Military Performance

Name	Carolyn Dartt, MEd, ATC
Project Role	Research Coordinator
Research Identifier	
Nearest person month worked:	39
Contribution to Project	Ms. Dartt assisted in data collection, data management, creating study forms, coordination with SOI-W, consenting, and manuscript preparation.
Funding Support:	--
Name	Catherine Donahue, MEd, ATC
Project Role	Research Coordinator
Researcher Identifier:	
Nearest person month worked:	24
Contribution to Project	Ms. Donahue assisted in data collection, data management, creating study forms, coordination with SOI-W, consenting, and manuscript preparation.
Funding Support:	--
Name	Amelia Barrett, MS, ATC
Project Role	Project Coordinator
Researcher Identifier:	
Nearest person month worked:	1
Contribution to Project	Ms. Barrett assisted in data collection, data management, creating study forms, IRB coordination, consenting, and manuscript preparation.
Funding Support:	Other Research Awards through Dr. de la Motte/Henry M. Jackson Foundation
Name	Daniel Clifton, PhD, ATC
Project Role	Research Associate
Researcher Identifier:	
Nearest person month worked:	1
Contribution to Project	Dr. Clifton assisted in data collection and management, creating study forms, IRB coordination, consenting, and manuscript preparation.
Funding Support:	Other Research Awards through Dr. de la Motte/Henry M. Jackson Foundation
Name	John Tra, PhD
Project Role	Biostatistician
Researcher Identifier:	
Nearest person month worked:	0.4
Contribution to Project	Dr. Tra assisted in data management, statistical analysis, manuscript preparation, and publication.
Funding Support:	Other Research Awards through Dr. de la Motte/Henry M. Jackson Foundation

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

If there is nothing significant to report during this reporting period, state "Nothing to Report."

If the active support has changed for the PD/PI(s) or senior/key personnel, then describe what the change has been. Changes may occur, for example, if a previously active grant has closed and/or if a previously pending

grant is now active. Annotate this information so it is clear what has changed from the previous submission. Submission of other support information is not necessary for pending changes or for changes in the level of effort for active support reported previously. The awarding agency may require prior written approval if a change in active other support significantly impacts the effort on the project that is the subject of the project report.

Dr. de la Motte has received two new awards, and one active award has finished:

1. New Award: RITE-TRACC II: The Effects of a Targeted Injury Reduction Program at U.S. Marine Corps West Coast Entry Level Training. Marine Corps Recruit Depot, San Diego, Marine Corps Base Camp Pendleton. Congressionally Directed Medical Research Program, Defense Medical Research and Development Program, Joint Program Committee-5/Military Operational Medicine Research Program Intramural Award. Principal Investigator. 10% effort. \$1,440,000. November 2019-September 2022.
2. New Award: Predicting and Preventing Low Back Pain in MARSOC Raider Trainees, Marine Raiders and Marine Aviators at Camp Lejeune. Congressionally Directed Medical Research Program, Defense Medical Research and Development Program, Joint Program Committee-5/Military Operational Medicine Research Program Intramural Award. Principal Investigator. 10% effort. \$1,735,000. November 2019-September 2022.
3. Closed Award: Predicting Early Career Success in Female Marine Officers. Uniformed Services University Intramural Military Women's Health Award. **Principal Investigator.** \$250,000. October 2017-September 2019.

What other organizations were involved as partners?

If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe partner organizations – academic institutions, other nonprofits, industrial or commercial firms, state or local governments, schools or school systems, or other organizations (foreign or domestic) – that were involved with the project. Partner organizations may have provided financial or in-kind support, supplied facilities or equipment, collaborated in the research, exchanged personnel, or otherwise contributed.

Provide the following information for each partnership:

Organization Name:

Location of Organization: (if foreign location list country)

Partner's contribution to the project (identify one or more)

- Financial support;
- In-kind support (e.g., partner makes software, computers, equipment, etc., available to project staff);
- Facilities (e.g., project staff use the partner's facilities for project activities);
- Collaboration (e.g., partner's staff work with project staff on the project);
- Personnel exchanges (e.g., project staff and/or partner's staff use each other's facilities, work at each other's site); and
- Other.

SOI-W Infantry Training Battalion Command Staff

Camp Pendleton, CA

Facilities, collaboration

ITB command staff provided support by allowing study staff access to SOI-W students, combat instructors, and facilities. The ITB command staff facilitated study procedures and data collection both before and after training, and provided support for study staff in collecting data from training Marines and Marine Corps records. The ITB command staff also expressed support for implementing the IPC and assisted study staff in both developing the IPC and disseminating the materials.

SOI-W Infantry Training Battalion Combat Instructors

Camp Pendleton, CA

Facilities, collaboration

The ITB Combat Instructors provided support by assisting study staff in collecting data from training Marines, particularly in assembling enrolled Marines for testing upon SOI-W graduation. The ITB Combat Instructors also played an integral role in developing the IPC, providing feedback to study staff on the training timeline and structure, as well as providing information regarding the feasibility of the IPC. The ITB Combat Instructors accommodated education sessions from the study staff so that they could implement the IPC via a train-the-trainer method, and provided feedback to study staff on adjustments and adaptations for the IPC that would be beneficial.

US Marine Corps Force Fitness Instructors

SOI-W, Camp Pendleton, CA

Collaboration

The USMC Force Fitness Instructors located at SOI-W worked closely with study staff in developing and implementing the IPC. The Force Fitness Instructors' familiarity with the training environment of ITB, in combination with their knowledge of fitness and injury prevention helped the study staff develop an IPC that could be easily integrated into training and meet the needs of the ITB training companies.

US Marine Corps SMIP Athletic Trainers

SOI-W, Camp Pendleton, CA

Collaboration, Facilities

The USMC Sports Medicine and Injury Prevention athletic trainers at SOI-W worked closely with study staff throughout the project. The SMIP athletic trainers helped facilitate the initiation of the project, acted as liaisons with SOI-W Command Staff, and also assisted with data collection when possible. The SMIP athletic trainers were also integral in developing the IPC; their familiarity with the training environment and the injury trends at SOI-W helped study staff develop an IPC that addressed areas of the body that were often affected by training demands.

US Navy SMART Center Physicians and Athletic Trainers

SOI-W, Camp Pendleton, CA

Collaboration, Facilities

The US Navy Sports Medicine and Rehabilitation Training Center physicians and athletic trainers provided support for the study throughout its duration. In addition to allowing study staff access to the SMART center and office space, the SMART Center physicians and athletic trainers provided input in developing the IPC.

Naval Health Research Center

San Diego, CA

Collaboration

The Naval Health Research Center provided access to data collected via the Recruit Assessment Program at entry to Basic Training. This program collects data on psychological measures and certain risk behaviors (e.g.: tobacco use). While these measures were not available for every subject enrolled in this study, the data provided by NHRC was a valuable addition to the study database and may also be useful in future research.

8. SPECIAL REPORTING REQUIREMENTS

COLLABORATIVE AWARDS: *For collaborative awards, independent reports are required from BOTH the Initiating Principal Investigator (PI) and the Collaborating/Partnering PI. A duplicative report is acceptable; however, tasks shall be clearly marked with the responsible PI and research site. A report shall be submitted to <https://ers.amedd.army.mil> for each unique award.*

QUAD CHARTS: *If applicable, the Quad Chart (available on <https://www.usamraa.army.mil>) should be updated and submitted with attachments.*

- 9. APPENDICES:** *Attach all appendices that contain information that supplements, clarifies or supports the text. Examples include original copies of journal articles, reprints of manuscripts and abstracts, a curriculum vitae, patent applications, study questionnaires, and surveys, etc.*

Appendix 1: Results Tables

Table 1. Subject Characteristics for ITB Marines with Complete Pre/Post Data

Table 2. Military Occupational Specialties (MOS) for ITB Marines with Complete Pre/Post Data

Table 3. Aim 1: Associations between Potential Predictor Variables and LE MSK-I During ITB

Table 4. Aim 1: Multivariate Analysis of Associations Between Predictor Variables and LE MSK-I During ITB

Table 5. Aim 1: Multivariate Analysis of Associations Between Care-Seeking, Predictor Variables, and LE MSK-I During ITB

Table 6. Aim 2: LE MSK-I During ITB for Aim 1 and Aim 2 Groups

Table 7. Aim 2: Summary of ITB Training Company Enrollment for Aim 1 and Aim 2 Groups

Table 8. Aim 2: Effect of Injury Prevention Curriculum on LE MSK-I During ITB

Table 9. Aim 2: Summary of Self-Reported Dynamic Warm Up Compliance by ITB Training Company

Table 10. Aim 2: Summary of Self-Reported Stretching Compliance by ITB Training Company

Table 11. Aim 2: Summary of Self-Reported IPC Effects on MSK-P During SOI-W Training

Appendix 2: Injury Prevention Curriculum – Dynamic Warm Up and Cool Down

Tactical Ten Warm Up and Cool Down Resource Page

Tactical Ten Warm Up and Cool Down IPC Cards

Appendix 3: Injury Prevention Curriculum – Sleep, Nutrition, and Hydration Education

Performance Nutrition Poster

Fueling for Performance Poster

Optimizing Rest and Recovery Poster

Table 1. Subject Characteristics for ITB Marines with Complete Pre/Post Data (N=585)				
Characteristic	Aim 1 (n=306)	Aim 2 (n=279)	Independent t- statistic	p-value
Age (years)	19.74 ± 1.72	19.56 ± 1.54	1.41	0.16
Height (cm)	176.53 ± 7.46	177.31 ± 7.44	-0.80	0.43
Weight (kg)	74.42 ± 7.9	74.86 ± 9.75	-0.36	0.72
Body Mass Index	23.8 ± 2.1	23.79 ± 2.5	0.30	0.77

Table 2. Military Occupational Specialties (MOS) for ITB Marines with Complete Pre/Post Data (N=585)

MOS	Title	Aim 1 (n=306)		Aim 2 (n=279)		TOTAL (N=585)	% Total
0300	Basic Infantry Marine	21	6.9%	13	4.7%	34	5.8%
0311	Infantry Rifleman	180	58.8%	163	58.4%	343	58.6%
0331	Infantry Machine Gunner	25	8.2%	46	16.5%	71	12.1%
0341	Infantry Mortarman	34	11.1%	32	11.5%	66	11.3%
0351	Infantry Assault Marine	18	5.9%	15	5.4%	33	5.6%
0352	Antitank Missile Gunner	20	6.5%	10	3.6%	30	5.1%
MOS Missing/ Did not graduate		8	2.6%	3	1.1%	11	1.9%
TOTAL		306		276		585	

Table 3. Aim 1: Associations between Potential Predictor Variables and LE MSK-I During ITB							
*variable included in full model							
	LE MSK-Injury During ITB (N=548)						
	No		Yes				
	n	%	n	%			
	505	92%	43	8%			
Age (n=547)					Independent t - statistic(545)	p- value	
Mean ± SD		19.60 ± 1.59		19.89 ± 2.01		-0.92	0.36
TOTAL		504	92%	43	8%		
Military Occupational Specialty (n=543)*					Pearson X2 Value	p- value	
Infantry Rifleman (0311)		304	61%	30	70%	1.35	0.25
Infantry Non-Rifleman (0300, 0331, 0341, 0351, 0352)		196	39%	13	30%		
TOTAL		500		43			
Tobacco User (n=526)							
No		216	45%	18	44%	0.006	0.94
Yes		269	56%	23	56%		
TOTAL		485		41			
Overall Health (n=544)							
Poor/Fair		11	2%	0	0%	3.05	0.29
Good		115	23%	14	33%		
Very Good/ Excellent		376	75%	28	67%		
TOTAL		502		42			
Health Compared to 1 Year Ago (n=548)							
Worse than 1 Year Ago		31	6%	5	12%	2.04	0.36
About the Same as 1 Year Ago		102	20%	9	21%		
Better Now Than 1 Year Ago		372	74%	29	67%		
TOTAL		505		43			
Fitness Compared to Others Same Age (n=548)							
Less Fit		10	2%	2	5%	2.65	0.27
Average		125	25%	7	16%		
More Fit		370	73%	34	79%		
TOTAL		505		43			
History of Ankle Sprain (n=548)							
No		367	73%	30	70%	0.17	0.68
Yes		138	27%	13	30%		
TOTAL		505		43			

Table 3 (continued). Aim 1: Associations between Potential Predictor Variables and LE MSK-I During ITB *variable included in full model

	LE MSK-Injury During ITB (N=548)					
	No		Yes			
	n	%	n	%		
	505	92%	43	8%		
History of MSK-I in Basic Training (n=547)						
No	438	87%	35	81%	1.03	0.31
Yes	66	13%	8	19%		
TOTAL	504		43			
MSK-Pain (MSK-P) During Basic Training (n=545)*						
No	366	73%	25	58%	4.26	0.04
Yes	136	27%	18	42%		
TOTAL	502		43			
Experiencing MSK-P Upon Entry to SOI (n=543)*						
No	473	95%	38	88%	2.77	0.16
Yes	27	5%	5	12%		
TOTAL	500		43			
BMI Category (n=336)						
Under/ Normal Weight (18.4-24.9)	210	68%	22	76%	0.69	0.41
Overweight (25-29.9)	97	32%	7	24%		
TOTAL	307		29			
In-Line Lunge Score (n=298)						
0/1	60	22%	8	30%	0.78	0.38
2/3	211	78%	19	70%		
TOTAL	271		27			
Active Straight Leg Raise Score (n=302)*						
0/1	55	20%	10	36%	3.68	0.06
2/3	219	80%	18	64%		
TOTAL	274		28			
Trunk Stability Push Up (n=302)						
0/1	9	3%	1	4%	0.007	1.00
2/3	265	97%	27	96%		
TOTAL	274		28			
Landing Error Scoring System Overall Impression (n=122)						
Poor	30	28%	3	23%	0.14	1.00
Average/ Excellent	77	72%	10	77%		
TOTAL	107		13			

Table 3 (continued). Aim 1: Associations between Potential Predictor Variables and LE MSK-I During ITB **variable included in sub-analysis model

	LE MSK-Injury During ITB (N=548)					
	No		Yes			
	n	%	n	%		
	505	92%	43	8%		
Medical Attention for MSK-I in Basic Training (n=70)**					Pearson X2 Value	p- value
Never Injured	438		35		5.19	0.04
Injured and Sought Medical Attention	51	81%	3	43%		
Injured and Did Not Seek Medical Attention	12	19%	4	57%		
TOTAL	63		7			
MSK-I During Basic Training Healed (n=70)						
Never Injured	437		35		0.00	1.00
Injured And It Has Healed	54	86%	6	86%		
Injured And It Has Not Healed	9	14%	1	14%		
TOTAL	63		7			
Medical Attention for MSK-P During Basic Training (n=153)						
No Pain	366	73%	25	58%	0.61	0.44
Had Pain and Sought Medical Attention	58	43%	6	33%		
Had Pain and Did Not Seek Medical Attention	77	57%	12	67%		
TOTAL	135		18			

Table 4. Aim 1: Multivariate Analysis of Associations Between Predictor Variables and LE MSK-I During ITB (N=295)

Variable	Estimate	Odds Ratio	95% CI		p-value
Military Occupational Specialty					
Infantry Rifleman (0311)	0.30	1.35	0.56	3.23	0.51
Infantry Non-Rifleman (0300, 0331, 0341, 0351)	Ref	--	--	--	
MSK-Pain (MSK-P) During Basic Training					
No	Ref	--	--	--	0.07
Yes	0.78	2.18	0.95	4.99	
Experiencing MSK-P Upon Entry to SOI					
No	Ref	--	--	--	0.21
Yes	0.82	2.27	0.62	8.28	
Active Straight Leg Raise Score					
0/1	0.8	2.22	0.95	5.23	0.07
2/3	Ref	--	--	--	

Table 5. Aim 1: Multivariate Analysis of Associations Between Care-Seeking, Predictor Variables and LE MSK-I During ITB (N=70)					
Variable	Estimate	Odds Ratio	95% CI		p-value
Age					
	0.07	1.08	0.70	1.65	0.74
Military Occupational Specialty					
Infantry Rifleman (0311)	-0.46	0.63	0.11	3.58	0.60
Infantry Non-Rifleman (0300, 0331, 0341, 0351)	Ref	--	--		
Medical Attention for MSK-Injury in Basic Training					
Sought Medical Attention	Ref	--	--	--	0.04
Did Not Seek Medical Attention	1.74	5.67	1.12	28.74	

Table 6. Aim 2: LE MSK-I during ITB for Aim 1 and Aim 2 groups (N=549)

LE MSK-I During ITB	Aim 1 (n=268)		Aim 2 (n=281)		TOTAL (N=549)	% Total
Yes	27	10.1%	16	5.7%	43	7.8%
No	241	89.9%	265	94.3%	506	92.2%
TOTAL	268		281		549	

Table 7. Aim 2: Summary of ITB Training Company Enrollment for Aim 1 and Aim 2 Groups (N=585)

Training Company	Aim 1 (n=306)		Aim 2 (n=279)		TOTAL (N=585)	% Total
Alpha	79	26%	92	33.0%	171	29%
Bravo	60	20%	47	17.0%	107	18%
Charlie	65	21%	43	15.0%	108	19%
Delta	102	33%	97	35.0%	199	34%
TOTAL	306		279		585	

Table 8. Aim 2: Effect of Injury Prevention Curriculum on LE MSK-Injury During ITB (N=295)					
Variable	Estimate	Odds Ratio	95% CI		p-value
Injury Prevention Curriculum (IPC)					
IPC	-0.71	0.49	0.26	0.95	0.03
No IPC	Ref	--	--	--	
Training Company					
Bravo	-0.81	0.44	0.18	1.1	0.08
Charlie	-1.34	0.26	0.09	0.79	0.02
Delta	-0.91	0.4	0.19	0.87	0.02
Alpha	Ref	--	--	--	--
Military Occupational Specialty					
Infantry Rifleman (0311)	0.33	1.38	0.7	2.78	0.34
Infantry Non-Rifleman (0300, 0331, 0341, 0351)	Ref	--	--	--	

Table 9. Aim 2: Summary of Self-Reported Dynamic Warm Up Compliance by ITB Training Company (N=123)

Training Company	Alpha (n=36)		Bravo (n=15)		Charlie (n=19)		Delta (n=53)	
Led By Combat Instructors								
Never	0	0%	0	0%	0	0%	2	4%
1x Per Week	17	47%	9	60%	6	32%	14	26%
2-3x Per Week	17	47%	5	33%	13	68%	33	62%
4-5x Per Week	2	6%	1	7%	0	0%	4	12%
6+ x Per Week	0	0%	0	0%	0	0%	0	0%
On Own Time								
Never	15	42%	7	47%	5	26%	12	23%
1x Per Week	9	25%	4	27%	5	26%	10	19%
2-3x Per Week	7	19%	3	20%	4	21%	25	48%
4-5x Per Week	2	6%	1	7%	2	11%	4	8%
6+ x Per Week	1	3%	0	0%	3	16%	1	2%
Missing	2	6%	0	0%	3	16%	1	2%

Table 10. Aim 2: Summary of Self-Reported Stretching Compliance by ITB Training Company (N=123)

Training Company	Alpha (n=36)		Bravo (n=15)		Charlie (n=19)		Delta (n=52)	
Led By Combat Instructors								
Never	4	11%	2	13%	0	0%	2	4%
1x Per Week	14	39%	5	33%	8	42%	18	35%
2-3x Per Week	15	42%	7	47%	10	53%	27	52%
4-5x Per Week	2	6%	1	7%	0	0%	3	6%
6+ x Per Week	1	3%	0	0%	1	5%	2	4%
On Own Time								
Never	15	42%	5	33%	2	11%	11	21%
1x Per Week	5	14%	7	47%	5	26%	13	25%
2-3x Per Week	11	31%	1	7%	7	37%	22	42%
4-5x Per Week	2	6%	1	7%	3	16%	4	8%
6+ x Per Week	2	6%	0	0%	1	5%	2	4%
Missing	1	3%	1	7%	1	5%	0	0%

Table 11. Aim 2: Summary of Self-Reported IPC Effects on MSK-P During ITB Training (N=33)

	"IPC Made MSK-P During ITB Training..."									
IPC Component	A Lot Better		A Little Better		No Effect		A Little Worse		A Lot Worse	
Dynamic Warm Up (n=33)	10	30%	14	42%	7	21%	1	3%	1	3%
Stretching Exercises (n=28)	11	39%	10	36%	7	25%	0	0%	0	0%

Appendix 2: Injury Prevention Curriculum - Dynamic Warm Up and Cool Down

The Tactical Ten Warm Up and Cool Down resource page was provided to Combat Instructors during educational train-the-trainer sessions.

The Tactical Ten Warm Up and Cool Down IPC cards were printed , laminated, and cut into individual cards. These were provided to Combat Instructors and training Marines as a portable resource for the warm up and cool down.

Tactical 10 Warm Up

Exercise	Description	Coaching Cues
1. Up back over walking 	<p>Starting Position: Feet hip-width apart, arms at sides.</p> <p>Directions: While walking forwards, swing arms upward until directly overhead. Swing arms down and behind the body, then swing arms upward, over the head, and down behind the body until they return to your sides.</p>	<ul style="list-style-type: none"> • “Keep torso upright • “Move under control” • “Keep elbows straight”
2. Press press fling walking 	<p>Starting Position: Feet hip-width apart, arms raised up in front of body at shoulder height, elbows bent.</p> <p>Directions: While walking forwards, keep elbows bent and press arms backwards, pinching shoulder blades together before bringing arms back in front of the body. Repeat, then straighten elbows and press arms backwards while keeping elbows straight.</p>	<ul style="list-style-type: none"> • “Keep torso upright • “Move under control”
3. Hi jack/hi jill walking 	<p>Starting Position: Feet hip-width apart, arms raised up to side, elbows bent at shoulder height.</p> <p>Directions: While walking forwards, rotate your right arm downward so that the hand points towards the ground. Hold for 2 seconds, then rotate both arms so that right arm points upwards and left arm points downwards.</p>	<ul style="list-style-type: none"> • “Keep torso upright • “Move under control” • “Keep elbows high”
4. Body weight squats 	<p>Starting Position: Feet shoulder width apart, hands on hip bones</p> <p>Directions: Squat down slowly, sending hips back as if sitting in a chair. Knees bend to 90 degrees. Return to standing. Back stays flat throughout.</p>	<ul style="list-style-type: none"> • “Knees over toes” • “Keep knees from going past toes” • “Toes straight ahead” • “Sit back” • “Feet shoulder width apart”
5. Walking side lunges 	<p>Starting Position: Feet hip-width apart, hands on hips</p> <p>Directions: Take a long step to the side with the left foot and slowly lower body as close to parallel with the ground as you can. Push with bent leg to return to standing. Bring right leg to meet left leg. Repeat 10 times, then switch to the other side.</p>	<ul style="list-style-type: none"> • “Keep knees behind toes” • “Bend both knees to 90” • “Keep torso upright”
6. Walking knee to chest 	<p>Starting Position: Feet hip-width apart, hands at sides.</p> <p>Directions: Step with left foot and raise right knee as high as possible. Grab right knee with both arms and hug knee towards chest. Hold for 2 seconds, then release knee and lower leg back to ground slightly in front of you. Alternate legs.</p>	<ul style="list-style-type: none"> • “Bring foot down <i>quietly</i>” • “Toes straight ahead” • “Keep torso upright • “Move under control”
7. Step and reach 	<p>Starting Position: Left foot with knee bent, hands at sides</p> <p>Directions: Extend arms by ears and tip forward at the hips, extending right leg to the rear. Keep hips level. Return to standing. Repeat 5 times, then switch to the other side.</p>	<ul style="list-style-type: none"> • “Keep back flat” • “Keep hips level” • “Straight line from ear through hip to ankle” • “Move under control”
8. Open/close gate 	<p>Starting Position: Feet hip-width apart, hands at sides.</p> <p>Directions: Step with left foot, then swing right knee up toward your chest and open your hip by bringing the left knee to the outside before lowering leg back to ground to your side. Tap the foot then bring the leg up to the side and swing the left knee back in front of your body and place back down on the ground. Alternate legs.</p>	<ul style="list-style-type: none"> • “Bring foot down <i>quietly</i>” • “Toes straight ahead” • “Keep torso upright • “Move under control”
9. Power skip (distance) 	<p>Starting Position: Feet hip-width apart, hands at sides</p> <p>Directions: Step with left foot, then hop and land on left leg, followed by same action on opposite leg. Repeat in a smooth, skipping motion, hopping as far forward as possible on each step.</p>	<ul style="list-style-type: none"> • “Land <i>softly</i> toe to heel” • “Toes straight ahead” • “Keep torso upright”
10. Squat jumps 	<p>Starting Position: Squat position, arms in ready position in front</p> <p>Directions: Jump up for maximum height and return to start position. Land softly toe to heel. Control the landing by bending at the hips, knees, and ankles.</p>	<ul style="list-style-type: none"> • “Land <i>softly</i> toe to heel” • “Bend at the hips, knees, and ankles” • “Knees over toes” • “Toes straight ahead” • “Jump for maximum height”

Cool Down and Stretch

Exercise

Description

Coaching Cues

1. Stretch calves



Start in a plank position. Cross your right foot behind your left and use your hands to push your body backward. Gently push your heel down, trying to touch your heel to the floor. Repeat stretch with knee slightly bent. Repeat on other leg.

- Hold each stretch 30 seconds
- Repeat each stretch 2 times

2. Stretch quads



While standing, bend one leg back towards buttocks, stretching front of leg. Repeat on other side.

- Keep knees parallel, underneath hips.
- Keep torso upright
- Hold each stretch 30 seconds
- Repeat each stretch 2 times

3. Stretch hamstrings



From a seated position, extend both legs out towards the side. While keeping back straight, lean forward towards left leg and bring chest toward knee. Repeat stretch to middle and right leg.

- Keep back flat and point chin towards toes.
- Hold each stretch 30 seconds
- Repeat each stretch 2 times.

4. Butterfly stretch



Begin by sitting with legs bent and bottoms of feet together. Grasp ankles and push legs towards floor using elbows while bending upper torso towards feet keeping back flat.

- Keep back flat
- Hold each stretch 30 seconds
- Repeat each stretch 2 times

5. Figure 4 stretch



On the floor in a supine position with knees bent and feet on floor, place left foot on right knee. Bend at the hips and bring your right knee towards your chest. Repeat on other side.

- If you need a deeper stretch, keep your feet on the floor and gently press out on your left knee with your left hand.
- Hold each stretch 30 seconds
- Repeat each stretch 2 times

6. Stretch hip flexors



Begin kneeling on floor with toes point straight and back. Move one leg forward until knee of forward leg is directly over ankle of forward foot. Without changing position of either leg, lower front of hip downward until stretch is felt in the front of the kneeling leg. Repeat on other side.

- Keep back flat
- Hold each stretch 30 seconds
- Repeat each stretch 2 times

- | Order | Tactical 10 Warmup |
|-------|-------------------------------------|
| 1 | Up back over walking |
| 2 | Press press fling walking |
| 3 | Hi jack/hi jill walking |
| 4 | DL squats |
| 5 | Walking side lunge (switch halfway) |
| 6 | Walking knee to chest |
| 7 | Step and reach |
| 8 | Open/close gate |
| 9 | Power skip (distance) |
| 10 | Squat jumps |

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Order	Cool Down/Stretch
1	Stretch calves
2	Stretch quads
3	Stretch hamstrings
4	Butterfly stretch
5	Figure 4 stretch
6	Stretch hip flexors

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5	Figure 4 stretch
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Appendix 3: Injury Prevention Curriculum - Sleep, Nutrition, and Hydration Education

These posters were printed 11"x14", laminated, and all were posted in visible areas throughout the ITB living quarters.

PERFORMANCE NUTRITION

FUEL UP FOR PERFORMANCE

- High-carbohydrate snacks provide energy for a workout or activity.
 - ◇ Consume 30–60 minutes before exercise.
 - ◇ Example: Greek yogurt with fruit.
 - ◇ MRE: Jam/jelly w/bread, First Strike® bar, pudding cup, muffin, and milk.



REFUEL AND RECOVER

- Balance of carbs and protein, plus plenty of fluids.
 - ◇ It takes at least 24 hours to replenish muscle glycogen stores after exercise or operations.
 - ◇ Your body needs carbohydrates to replenish muscle glycogen stores.
 - ◇ And your body needs protein to rebuild muscle.
- Consume a recovery snack or meal within 45 minutes after activity.
 - ◇ Example: Chocolate milk w/fruit, pita w/hummus and veggies, tuna and crackers, fruit and nut mix.
 - ◇ MRE: Chicken fajita with tortilla, beans, and salsa.



DRINK UP!

- Hydrate with water or sports drinks throughout the day.
- Monitor your hydration status by weight or urine color.
- Avoid excessive alcohol and energy drinks – these can cause dehydration.
- Energy drinks often contain more than one serving. Read labels carefully!
- Make sure you consume less than 400 mg of caffeine per day.



FUELING FOR PERFORMANCE

DAILY FUELING

Supports normal activity, repairs damaged tissues, and promotes muscle growth.

- ◇ Balanced diet of carbs, protein, healthy fats, and lots of fluids.
- ◇ Example: Lean protein, whole grains, fruits and vegetables, and low-fat dairy products.
- ◇ MREs: If you need to strip them, prioritize the entrée – It contains the necessary carbs, protein, vitamins, and nutrients to fuel you best.

OPTIMIZE PERFORMANCE: SNACK WISELY

At convenience stores, choose healthier options such as fruit, bagged pretzels, 100% fruit juice, beef jerky, baked chips, snack-size packages of unsalted nuts, string cheese, hard-boiled eggs.

UPGRADE YOUR FAST FOOD

Make sensible food choices and find healthy alternatives to a burger and fries, such as:

- ◇ Wendy's Mandarin chicken salad
- ◇ Subway 6" deli turkey sub
- ◇ Subway breakfast Western egg with cheese
- ◇ Taco Bell bean burrito
- ◇ Soldier Fuel bar



SKIP THIS

DOUBLE CHEESEBURGER

SUPER-SIZE FRIES

PEPPERONI-LOVER'S PIZZA

BURRITO SUPREME

THICK CRUST PIZZA

BREADED CHICKEN SANDWICH

LARGE SODA

CHEESEBURGER

SMALL FRIES

CHEESE PIZZA

SOFT CHICKEN TACO

THIN CRUST PIZZA

GRILLED CHICKEN

SODA WATER

TRY THIS

IMPROVING PERFORMANCE: Optimize Rest and Recovery



POWER UP WITH NAPS AND SLEEP BANKING

When you have time, get extra sleep to make up for sleep deficits during the week. Sleep as long as you can, as often as you can, especially on your days off.

Nap for a quick recharge. Power naps boost memory, mind, and energy. Naps of any length help reduce sleep debt.



CREATE A SLEEP-FRIENDLY ENVIRONMENT

Reduce noise and light when possible. Use eye masks, headphones, or earplugs to help you sleep.

Create agreements with roommates/bunkmates to establish “quiet times.”



UNDERSTAND THE IMPACT OF ELECTRONICS ON SLEEP

Electronic devices emit “blue light” that can prevent you falling asleep.

Turn off smartphones, tablets, video games, and computers at least an hour before bedtime.

Turn off the TV before you fall asleep.



BE SMART ABOUT CAFFEINE

Caffeine can help temporarily maintain performance when you can't get enough sleep, but it also promotes wakefulness and disrupts sleep.

Stop caffeine intake at least 6 hours before bedtime.



WATCH WHAT YOU CONSUME BEFORE BED

Avoid large meals, alcohol, and tobacco before bedtime. These reduce sleep quality and increase nighttime waking.